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Quantifying thermophysical, mechanical, and transport properties of regolith-derived materials for in-space manufacturing (B-005 Regolith Materials)

Louisiana Board Of Regents

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This proposal is in response to Research Identifier B.005, and specific to the focus areas Studies of the extracted material to determine its properties&" and Investigations to determine manufacturing processes using regolith or materials extracted from regolith..." Of particular importance in the ultimate application of regolith for in-situ resource utilization is to understand fundamental material properties that are not readily available and difficult to measure. These properties are critical to enable hi-fidelity process modeling and development particular to the in-space processes currently in development.

Several methods of additive manufacturing (AM) are currently under investigation for application in micro- and reduced-gravity environments including bound metal deposition (BMD), wire+arc AM, and laser-based fusion methods, all of which include either the generation of a melt pool or surface wetting of the metal alloy feedstock to facilitate generation of the desired geometry. The evolution of the liquid phase, in-turn, is influenced heavily by the gravitational field, with samples undergoing distortion relative to the gravitational environment. An important aspect of the optimization of processes for ISM, independent of the method, is the development of robust models and simulation. ISM models must therefore utilize methods such as phase field that can incorporate field effects like gravity in the evolution of the as-built structure and properties, and capture effects of melting, formation of interfacial phases, and segregation.

This project will build upon recent in-space manufacturing advances by the proposing team to measure thermophysical, thermochemical, and structural properties of alloys derived from regolith simulant, namely Fe-xSi and Al-xSi alloys. Methods for quantifying material properties will include thermophysical properties (melting range, heat capacity, viscosity, density) via electrostatic levitation at MSFC, surface and interfacial energy through sessile drop contact angle measurements, phase evolution through in-situ high temperature XRD, and thermal and electrical transport properties as a function of temperature through PPMS measurements. Based on feedback with the ISM team, experiments will be repeated with optimized compositions and environmental conditions needed for model validation. This work will support the investigation into the applicability of these materials for in-space manufacturing processes, through the comprehensive characterization of feedstock properties, and will facilitate development of a sustainable collaboration conducting future studies directly impacting ISRU and ISM process and simulation improvements.